

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization International Bureau



(43) International Publication Date  
3 June 2004 (03.06.2004)

PCT

(10) International Publication Number  
**WO 2004/046995 A3**

(51) International Patent Classification<sup>7</sup>: G06F 19/00, G06T 5/00

(21) International Application Number: PCT/IB2003/005136

(22) International Filing Date: 12 November 2003 (12.11.2003)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data: 02079814.6 20 November 2002 (20.11.2002) EP

(71) Applicant (for AE, AG, AL, AM, AT, AU, AZ, BA, BB, BE, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CY, CZ, DK, DM, DZ, EC, EE, EG, ES, FI, FR, GB, GD, GE, GH, GM, GR, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, SZ, TJ, TM, TN, TR, TT, TZ, UA, UG, UZ, VC, VN, YU, ZA, ZM, ZW only): KONINKLIJKE PHILIPS ELECTRONICS N.V. [NL/NL]; Groenewoudseweg 1, NL-5621 BA Eindhoven (NL).

(71) Applicant (for DE only): PHILIPS INTELLECTUAL PROPERTY & STANDARDS GMBH [DE/DE]; Stein-damm 94, 20099 Hamburg (DE).

(72) Inventor; and

(75) Inventor/Applicant (for US only): WIEMKER, Rafael [DE/DE]; c/o Prof. Holstlaan 6, NL-5656 AA Eindhoven (NL).

(74) Agent: SCHOUTEN, Marcus, M.; Philips Intellectual Property & Standards, Prof. Holstlaan 6, NL-5656 AA Eindhoven (NL).

(81) Designated States (national): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

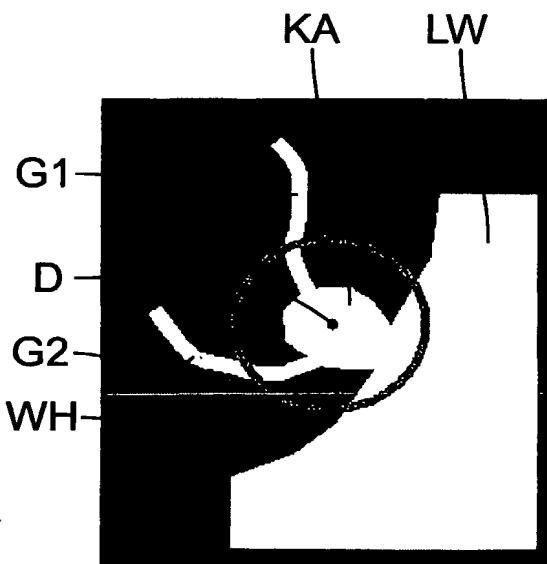
(84) Designated States (regional): ARIPO patent (BW, GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— with international search report

[Continued on next page]

(54) Title: COMPUTER-AIDED DETECTION OF LUNG NODULES



(57) Abstract: The invention relates to a method and a device for forming an image of body structures from an image data set, notably for highlighting potential nodular structures (KI; KA) in a lung. The problem to be solved by the invention is to achieve automatic highlighting of potential nodular structures in methods of this kind. This is realized in that in a plurality of steps a binary data set is formed in which all pixels present in the image data set are subdivided into pixels to be marked and those not to be marked, a first filtering operation being performed in which for each pixel (D) there is determined a distance value which corresponds to the shortest distance between the pixel and the edge (KAG) of the image structure (KA) in which the pixel is situated, those pixels being selected from the binary data set whose distance value is below a predetermined distance limit value, there being performed a second filtering operation in which those previously selected pixels remain selected which are directly neighbored by two pixels having a smaller distance value in both directions of at least one straight line which extends through the pixel, there being performed a third filtering operation in which those previously selected pixels remain selected for which the surrounding pixels, being situated at a distance corresponding to the distance value of the pixel, have a distance value which is a predetermined distance difference value smaller than the distance value of the pixel to be tested itself, the pixels thus selected being used to form an image in which the selected pixels are highlighted.

WO 2004/046995 A3



- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(88) Date of publication of the international search report:  
22 July 2004

# INTERNATIONAL SEARCH REPORT

onial Application No

PCT/IB 03/05136

**A. CLASSIFICATION OF SUBJECT MATTER**  
 IPC 7 G06F19/00 G06T5/00

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)  
 IPC 7 G06F G06T

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ, INSPEC

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>SHYH-LIANG LOU ET AL: "Object-based deformation technique for 3D CT lung nodule detection"          PROC. SPIE - INT. SOC. OPT. ENG. (USA), PROCEEDINGS OF THE SPIE - THE INTERNATIONAL SOCIETY FOR OPTICAL ENGINEERING, 1999, SPIE-INT. SOC. OPT. ENG, USA, vol. 3661, pt.1-2, February 1999 (1999-02), pages 1544-1552, XP002279163          ISSN: 0277-786X          cited in the application          the whole document</p> <p>-----</p>	1-14
P,A	<p>DE 101 60 206 A (PHILIPS INTELLECTUAL PROPERTY) 18 June 2003 (2003-06-18)          the whole document</p> <p>-----</p> <p>-----</p>	1-14



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

° Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the International filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the International filing date but later than the priority date claimed

"T" later document published after the International filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

6 May 2004

Date of mailing of the international search report

26/05/2004

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
 NL - 2280 HV Rijswijk  
 Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
 Fax: (+31-70) 340-3016

Authorized officer

Herter, J

## INTERNATIONAL SEARCH REPORT

International Application No

PCT/IB 03/05136

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WIEMKER R ET AL: "Computer-aided lung nodule detection on high-resolution CT data" PROCEEDINGS OF THE SPIE, SPIE, BELLINGHAM, VA, US, vol. 4684, May 2002 (2002-05), pages 677-688, XP002259534 ISSN: 0277-786X the whole document -----	1-14
A	US 6 078 680 A (KATSURAGAWA SHIGEHICO ET AL) 20 June 2000 (2000-06-20) abstract; figures 18-20 column 2, line 20 - column 4, line 24 column 6, line 28 - column 10, line 58 -----	1-14
A	MARYELLEN LISSAK GIGER ET AL: "COMPUTERIZED DETECTION OF PULMONARY NODULES IN DIGITAL CHEST IMAGES: USE OF MORPHOLOGICAL FILTERS IN REDUCING FALSE-POSITIVE DETECTIONS" MEDICAL PHYSICS, AMERICAN INSTITUTE OF PHYSICS, NEW YORK, US, vol. 17, no. 5, 1 September 1990 (1990-09-01), pages 861-865, XP000170779 ISSN: 0094-2405 the whole document -----	1-14
A	OKUMURA T ET AL: "Automatic detection of lung cancers in chest CT images by variable N-Quoit filter" PATTERN RECOGNITION, 1998. PROCEEDINGS. FOURTEENTH INTERNATIONAL CONFERENCE ON BRISBANE, QLD., AUSTRALIA 16-20 AUG. 1998, LOS ALAMITOS, CA, USA, IEEE COMPUT. SOC, US, 16 August 1998 (1998-08-16), pages 1671-1673, XP010297677 ISBN: 0-8186-8512-3 the whole document -----	1-14
A	MITANI Y ET AL: "A Gabor filter-based classification for diffuse lung opacities in thin-section computed tomography images" KNOWLEDGE-BASED INTELLIGENT ENGINEERING SYSTEMS AND ALLIED TECHNOLOGIES, 2000. PROCEEDINGS. FOURTH INTERNATIONAL CONFERENCE ON BRIGHTON, UK 30 AUG.-1 SEPT. 2000, PISCATAWAY, NJ, USA, IEEE, US, 30 August 2000 (2000-08-30), pages 780-783, XP010523714 ISBN: 0-7803-6400-7 the whole document -----	1-14

-/-

## INTERNATIONAL SEARCH REPORT

National Application No  
US/IB 03/05136

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>CHIOU Y S P ET AL: "Neural-knowledge base object detection in Hybrid Lung Nodule Detection (HLND) system"            NEURAL NETWORKS, 1994. IEEE WORLD CONGRESS ON COMPUTATIONAL INTELLIGENCE., 1994 IEEE INTERNATIONAL CONFERENCE ON ORLANDO, FL, USA 27 JUNE-2 JULY 1994, NEW YORK, NY, USA, IEEE, 27 June 1994 (1994-06-27), pages 4180-4185, XP010128047            ISBN: 0-7803-1901-X            the whole document</p> <p>-----</p>	1-14
A	<p>US 5 987 094 A (CLARKE LAURENCE P ET AL)            16 November 1999 (1999-11-16)            abstract; figure 1            column 1, line 22 - column 5, line 28</p> <p>-----</p>	1-14

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

IB 03/05136

Patent document cited in search report	Publication date		Patent family member(s)	Publication date
DE 10160206	A 18-06-2003	DE WO	10160206 A1 03049040 A2	18-06-2003 12-06-2003
US 6078680	A 20-06-2000	AU WO	8509998 A 9905639 A1	16-02-1999 04-02-1999
US 5987094	A 16-11-1999	US	2003026503 A1	06-02-2003

WO 2004/046995 A2



*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*